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# **Early Implementation of BIM into a Cold-Formed Steel Design/ Fabricator and an Architectural/Planning Consultancy**

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## **ABSTRACT**

There is a broad consensus surrounding the ability of building information modelling (BIM) to positively impact a project by enabling greater collaboration. This paper aims to examine the development of BIM and how it can contribute to the evermore present and growing cold-formed steel (CFS) industry. This is achieved thorough a comprehensive literature review and four exploratory interviews with industry experts. Work has been carried out, for the first time, alongside one of the UK's largest CFS Designer/Fabricators in conjunction with Northern Ireland's leading Architectural and Town Planning Consultants in the identification and dissemination of information. The capabilities of BIM have been investigated through modeling of simple CFS structures n consultation with the project partners. By scrutinising the literature and associated interviews, the primary opportunities, as well as barriers, of BIM implementation have been investigated in the context of these companies. It is essential to develop greater understanding of the flexibility, adaptability and interoperability of BIM software as the UK construction industry faces a daunting challenge; fully collaborative 3D BIM as required by the UK Government under the "Government Construction Strategy" by 2016 in all public sector projects. This paper, and the wider study that it stems from, approaches the problem from a new angle, from sections of the construction industry that have not yet fully embedded BIM.

**Keywords:** Building Information Modelling, Navisworks, Revit, Portal Frame, Collaboration.

## **INTRODUCTION**

The premise behind Building Information Modelling (BIM) has existed in the Architecture, Engineering and Construction (AEC) industry for the last 40 years (Nisbet & Dinesen, 2010). It is only now really starting to be rooted into industry with a mandate set by the Government for it to be operational in all public sector projects by 2016 (Cabinet Office, 2011). The mandate has come about after numerous studies have shown that the construction industry has become somewhat fragmented in the nature of its processes (Gillies, 2012; Keys et al., 2000; Osmani, 2011). Teicholz (2004) identifies that labour productivity in the construction industry is lagging somewhat behind other non-farm industries. This has been linked to the traditional approach in which many projects are delivered, through the use of 2D Computer Aided Design (CAD), and the sheer size of some construction firms. The traditional approach impedes the ability to collaborate as roles are often fragmented, and phases such as design and construction are treated separately. To move away from the somewhat antagonist methods of construction, reflective of traditional methods, BIM is a means of introducing new ideas and new ways of saving time, money and reducing waste in the industry. Reports by Sir John Egan (1998) and Sir Michael Latham (1994) have been pivotal in making the construction industry aware of its inefficiencies and calling them to act. The 'Latham Report' (1998) drew particular attention to improving the link between design and construction. Both reports set targets for reduction in waste, whether it is in the form of construction cost, time or defects, and with the introduction of BIM a paradigm shift is being evidenced in the design and costing process.

Where a gap in knowledge exists is the early application of BIM in the cold-formed steel (CFS) market including Architectural firms. As a result of the advancement and the availability of higher strength materials, CFS as a primary framing component has become more attractive and CFS portal frames have been developed as a viable alternative to traditional hot rolled I-sections, especially for more modest spans, around 18m (Rahman et al., 2011; Phan et al., 2012; Dundu & Kemp, 2006; Johnston et al., 2013). This paper looks to examine the cold-formed steel (portal) frame industry which has not yet embraced BIM within their practices but seeks to discover how, through its implementation, their systems can be improved. This project has been created in close communication with the largest CFS designer/fabricators in the UK in conjunction with Ostick and Williams Ltd. (Architectural and Town Planning Consultants), located in Belfast, Northern Ireland. On completion of this project, the CFS industry in conjunction with the AEC sector as a whole will have a reference of how CFS buildings can be created using BIM and, the interoperability between the ranges of software's demonstrated. This can only benefit those companies considering implementation and aid in the transition from their traditional methods to a fully collaborative 3D BIM.

## **METHODOLOGY**

A number of methods were utilized in the study in order to fully investigate the research problem. To demonstrate BIM capabilities, a cold-formed steel portal frame was modeled using Autodesk's Revit 2013. The model was created using information supplied by the UK's largest CFS design company while also discussing the design and modeling process with Ostick and Williams. To aid both companies in transitioning towards BIM utilisation, the process of creation was recorded in the report through the use of video (e-learning) and rich text, drawing attention to any key issues that will ensure a smooth transition of adoption from 2D based practice to 3D BIM. A thorough literature review was conducted to define and gain an understanding of BIM. The benefits of BIM were then investigated with particular attention drawn to its role in managing projects and integrating project delivery. To further validate the study a series of exploratory interviews were conducted with industry experts from both organisations. The resultant qualitative data were subsequently analysed using nVivo 10, enabling the creation of word clouds, expanding themes and promoting discussion of those most prevalent to the study.

## **BIM AND CFS**

Within the AEC industries there is a heightened euphoria surrounding BIM (Gallelo, 2008) and its implementation in the AEC sector. This revolutionary technology and process is beginning to reshape traditional forms of design and construction by allowing project stakeholders to visualise, in a simulated environment, proposed projects at the inception stage of development. This has a number of advantages; more notably the ability to quickly identify any issues with regards the design, constructability and operation of the project, and through close collaboration with the affected parties, mitigating its potential impact (Azhar, 2011). Penttila, (2006) appreciates that BIM is more than a 3D CAD system that creates a building's geometrical data, but a methodology essential to manage the project data in a digital format throughout the building's lifecycle through interacting policies, processes and technologies (Succar, 2009). On top of this Eastman, et al., (2008) recognise the value of BIM for construction management, that is by using their tools, architects and engineers alike can produce models that contractors can subsequently use for estimating, coordination, construction planning, fabrication, procurement and other functions.

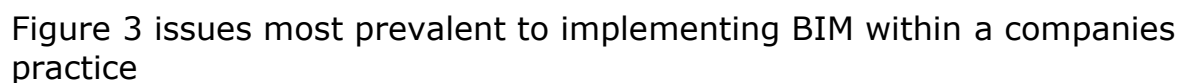
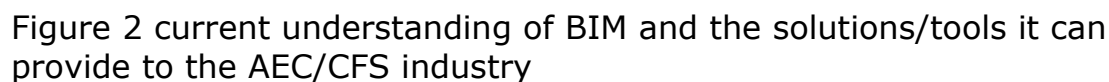
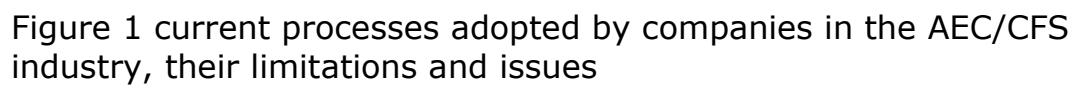
So why adopt BIM now? It is apparent after numerous studies including the influential reports of Egan, (1998) and Latham, (1994) that there is a vital need to improve efficiencies of the AEC industries. The construction sector is a major part of the UK economy representing some 7% of GDP or £110billion per annum of expenditure. (Cabinet Office, 2011) Thus it is imperative that BIM becomes ingrained in the AEC industry providing a

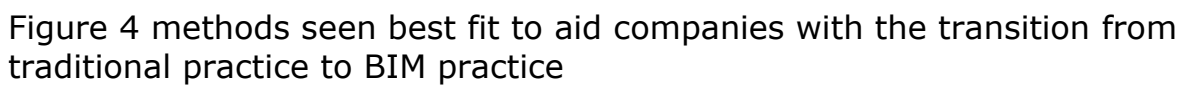
means of facilitating and ensuring greater success in the industry. By 2016, the UK government has mandated that a fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum, be made available under the "Government Construction Strategy", published by the UK Cabinet Office (Cabinet Office, 2011). This is with respect to all public sector projects and has spurred further interest in BIM within the AEC industry, but, there is still an element of confusion over what exactly needs to be in place before BIM based projects become a reality (Kumar, 2012). Reports produced by NBS, (2012) and the BIM Task Group, (2012) relay significant cost savings from design to construction as well as in facilities management. These benefits are echoed by a number of large UK construction firms. In one example, Nisbet & Dinesen, (2010) gave an example of major cost savings as a result of clash detection technology within BIM in the range of \$800,000.

So where does cold-formed steel (CFS) come into the equation? For years CFS was adopted in many secondary structural systems, such as purlins and side rails or floor joists, as well as in building envelopes. But in more recent years, higher strength materials have caused a more important development in CFS relative to the common heavier HRS structural members (Bayan et al., 2011). As a result CFS sections are used more and more as primary framing components (Uzzaman, et al., 2012). As a result, CFS portal frames have been developed as a viable alternative to traditional hot rolled I-sections, especially for more modest spans (around 18m) (Rahman et al., 2011; Phan et al., 2012; Dundu & Kemp, 2006; Johnston et al., 2013).

## **RESULTS**

The exploratory interviews conducted with four industry experts in BIM from both a CFS designer/fabricator and with Ostick and Williams determined the following areas to be of greatest significance. (1) The current processes adopted by companies in the AEC/CFS industry, their limitations and issues. (2) The current understanding of BIM and the solutions/tools it can provide to the AEC/CFS industry. (3) The issues most prevalent to implementing BIM within a company's practice. (4) The best methods seen to help companies with the transition from traditional practices to a fully collaborative BIM atmosphere. A comprehensive understanding of these four thematic areas can better equip companies to fulfil the Government's mandate for BIM proficiency by 2016, allowing them to procure for public sector project. The word clouds (figures 1-4), generated from coding each node in nVivo give a distinct summary of the most frequent terms discussed with regards each theme. The limitations within the AEC industry and more specifically, the CFS and Architectural industry are addressed along with barriers to BIM implementation.





It is evident that a number of issues must be resolved to ensure that companies can fully comprehend the technologies necessary for becoming BIM proficient. It seems that to teach those companies will require material that is specific to their in-house practices, be it in the form of videos, presentations and, structured documentation taking a team through the process. This will have to start off with the basics to create a solid base upon which to build, and in combination with knowledge providers, BIM working groups and Government support, those companies will become more able to achieve, in time, the benefits provided by BIM. The following screen shots depict the potential available using the design of a simple CFS portal frame structure in Revit.



Clash detection is demonstrated (figure 7) and alerts the user to any interference within the CFS portal frame model. Timeliner (figure 8) allows a 4D simulation of the construction; this can be integrated with a project schedule stored in Microsoft Project or Primavera. A mock schedule is created to demonstrate the virtual construction of the CFS portal frame and the ability to carry out time based clash detection. Although not demonstrated in this project, it is appreciated to mention that Navisworks 2014 allows for accurate model based quantification. Accurate cost forecasting and control is crucial for a successful construction project and the tools available through Autodesk mean that construction managers and estimators can more easily measure, count and price building objects to gain an in-depth understanding of project costs from design through delivery. This allows further benefits, allowing the track of changes between model revisions, the performance of destructive and constructive take-offs and the assignment of material and labour resources to items in the model (Autodesk, 2013).

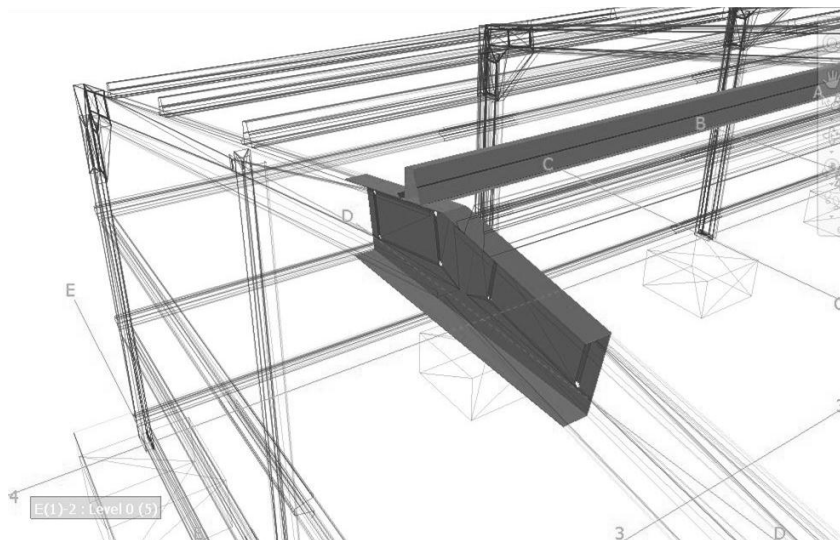


Figure 7: Navisworks 2013 Clash Detective

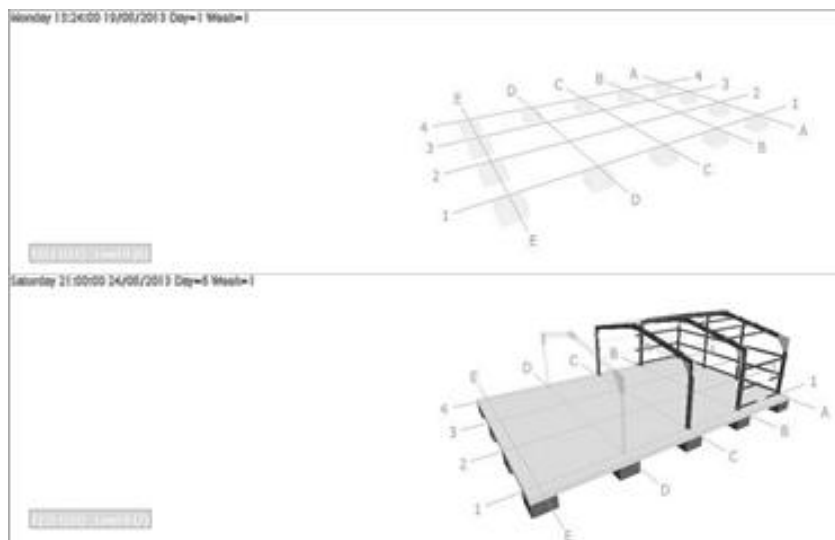


Figure 8: Navisworks Timeliner – Construction Sequencing



## CONCLUSION

This paper has given an account of the increasing popularity of BIM in the AEC market and its early integration into the CFS and Architectural sectors. It is clear from literature that BIM will have an integral role in reducing wastage in the construction industry, a key goal of the influential reports by Egan, (1998) and Latham, (1994). Where BIM will have a particular impact in the CFS and Architectural companies that aided in this study is in its ability to model non-standard buildings, say mono-pitches, L-shaped buildings, barns etc. that cannot be done through their current software. This will increase the company's flexibility in the works that they can procure and facilitate growth in the future. The information contained within the model also allows for accurate schedules to be created, resulting in reduced wastage and improved efficiency. By performing clash detective allows time based clashes to be detected. BIM adds the spatial aspect to the construction and demonstrates on screen the sequential activities of construction giving the construction team a greater ability to fine tune the programme and achieve savings in space and time.

The relevance of the study is clearly supported not only in the literature but also by those interviewed who believed that such a study was more relevant as it is industry lead, practical and, timely with the Government mandate requiring the use of BIM in all public sector projects come 2016. Companies need information that shows them how BIM will work for their situation. This project fills that gap in knowledge. This research will serve as a base for future studies, particularly in the CFS and Architectural industries where BIM's full potential is still to be realised. The ability to analyse the energy consumption of the building is one that will be of great interest to companies. To conclude, the findings in this report enhance our understanding of BIM and make a welcome contribution to the CFS and Architectural industries. BIM does indeed have a major part to play throughout the construction sector and will aid in the transition required by the Government, resulting in improved efficiencies in the construction industry and bringing productivity more in line with other manufacturing industries.

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